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## No. XXXVIII.

*The description of a Mould-board of the least resistance, and of the easiest and most certain construction, taken from a letter to Sir John Sinclair, President of the board of agriculture at London.*

Philadelphia, March 23, 1798.

Dear Sir,

Read May 4, 1798. I have to acknowledge the receipt of your two favours of June 21, and July 15, and of several separate parcels containing the agricultural reports. These now form a great mass of information on a subject, of all in the world, the most interesting to man: for none but the husbandman makes any thing for him to eat; and he who can double his food, as your exertions bid fair to do, deserves to rank, among his benefactors, next after his Creator. Among so many reports of transcendent merit, one is unwilling to distinguish particulars. Yet the application of the new chemistry, to the subject of manures, the discussion of the question on the size of farms, the treatise on the potatoe, from their universality have an advantage in other countries over those which are topographical. The work which shall be formed, as the result of the whole, we shall expect with impatience.

Permit me, through you, to make here my acknowledgments to the board of agriculture for the honour they have been pleased to confer on me by, associating me to their institution. In love for the art, I am truly their associate: but events have controuled my predilection for its practice, and denied to me that uninterrupted attention, which alone can enable us to advance in it with a sure step. Perhaps I may find opportunities of being useful to you as a sentinel at an outpost, by conveying intelligence of whatever may occur here new and interesting to agriculture. This duty I shall perform with pleasure, as well in respectful return for the

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### 314 DESCRIPTION OF A MOULD-BOARD.

notice of the board, as from a zeal for improving the condition of human life, by an interchange of its comforts, and of the information which may increase them.

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In a former letter to you I mentioned the construction of the mould-board of a plough which had occurred to me, as advantageous in its form, as certain and invariable in the method of obtaining it with precision. I remember that Mr. Strickland of York, a member of your board, was so well satisfied with the principles on which it was formed that he took some drawings of it ; and some others have considered it with the same approbation. An experience of five years has enabled me to say, it answers in practice to what it promises in theory. The mould-board should be a continuation of the wing of the ploughshare, beginning at its hinder edge, and in the same plane. Its first office is to receive the sod horizontally from the wing, to raise it to a proper height for being turned over, and to make, in its progress, *the least resistance possible* ; and consequently to require a minimum in the moving power. Were this its only office, the wedge would offer itself as the most \* eligible form in practice. But the sod is to be turned over also. To do this, the one edge of it is not to be raised at all ; for to raise this would be a waste of labour. The other edge is to be raised till it passes the perpendicular,

\* I am aware that were the turf only *to be raised* to a given height in a given length of mould-board, and not to be turned over, the form of least resistance would not be rigorously a wedge with both faces straight, but with the upper one curved according to the laws of the solid of least resistance described by the mathematicians. But the difference between the effect of the curved and of the plain wedge, in the case of a mould-board, is so minute, and the difficulty in the execution which the former would superinduce on common workmen is so great, that the plain wedge is the most eligible to be assumed in practice for the first element of our construction.

perpendicular, that it may fall over with its own weight. And that this may be done so as to give also the least resistance, it must be made to rise gradually from the moment the sod is received. The mould-board then, in this second office, operates as a transverse, or rising wedge, the point of which sliding back horizontally on the ground, the other end continues rising till it passes the perpendicular. Or, to vary the point of view, place on the ground a wedge of the breadth of the ploughshare, of its length from the wing backwards, and as high at the heel as it is wide. Draw a diagonal on its upper face from the left angle at the point to the right upper angle of the heel. Bevil the face from the diagonal to the right-bottom-edge which lies on the ground. That half is then evidently in the best form for performing the two offices of raising and turning the sod gradually, and with the least effort: and if you will suppose the same bevil continued across the left side of the diagonal, that is, if you will suppose a straight line whose length is at least equal to the breadth of the wedge, applied on the face of the first bevil and moved backwards on it parallel with itself and with the ends of the wedge, the lower end of the line moving along the right-bottom-edge, a curved plane will be generated, whose characteristic will be a combination of the principle of the wedge in cross directions, and will give what we seek, the *mould-board of least resistance*. It offers too this great advantage, that it may be made by the coarsest workman, by a process so exact that its form shall never be varied a single hair's breadth. One fault of all other mould-boards is that, being copied by the eye, no two will be alike. In truth it is easier to form the mould-board I speak of with precision, when the method has been once seen, than to describe that method either by words or figures. I will attempt however to describe it. Whatever may not be intelligible from the description may be supplied from the model I send you.

Let the breadth and depth of the furrow the farmer usually opens, as also the length of his plough-bar, from where it joins the wing to the hinder end, be given ; as these fix the dimensions of the block of which the mould-board is to be made. Suppose the furrow 9 inches wide, 6 inches deep, and the plough-bar 2 feet long. Then the block, Fig. 1. must be 9 inches wide at bottom (*b. c.*)  $13\frac{1}{2}$  inches wide at top, (*a. d.*) because if it were merely of the same width with the bottom as *a. e.* the sod, only raised to the perpendicular, would fall back into the furrow by its own elasticity. I find from experience, that, in my soil, the top of the mould-board should overjet the perpendicular  $4\frac{1}{2}$  inches in a height of 12 inches, to insure that the weight of the sod shall preponderate over its elasticity. This is an angle of nearly  $22^{\circ}$ . The block must be 12 inches high, because, unless the mould-board be in height double the depth of the furrow, in ploughing friable earth, it will be thrown in waves over the mould-board : and it must be 3 feet long, one foot of which is added to form a tail-piece, by which it may be made fast to the plough-handle. The first operation is to give the first form to this tail-piece, by sawing the block, Fig. 2. across from *a. b.* on its left side, (which is 12 inches from its hinder end) along the line *b. c.* to *c.* within  $1\frac{1}{2}$  inches of the right side, and to the corresponding point in the bottom,  $1\frac{1}{2}$  inches also from the side. Then saw in again at the hinder end from *d. e.* ( $1\frac{1}{2}$  inches from the right side) along the line *d. c.* The block *a. b. c. d. e. f. g.* drops out and leaves the tail-piece *c. d. e. b. i. k.*  $1\frac{1}{2}$  inches thick. The fore part of the block *a. b. c. k. l. m. n.* is what is to form the real mould-board. With a carpenter's square make a scribe all round the block at every inch. There will of course be 23 of them. Then from the point *k.* Fig. 2. and 3. draw the diagonals *k. m.* on the top, and *k. o.* Fig. 3. on the right side. Enter a saw at the  
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the point *m.* being the left-fore-upper corner, and saw in, guiding the hinder part of the saw along the diagonal *m. k.* (Fig. 2. 3.) and the fore part down the left edge of the block at the fore-end *m. l.* (Fig. 2.) till it reaches *k.* and *l.* in a straight line. It will then have reached the true central diagonal of the block *k. l.* Fig. 5. then enter the saw at the point *o.* being the right-fore-bottom corner, and saw in, guiding the hinder part of the saw along the diagonal *o. k.* (Fig 3.) and the fore part along the bottom edge of the fore end *o. l.* till it again reaches *k. l.* Fig. 5. the same central diagonal to which you had cut in the other direction. Consequently the pyramid *k. m. n. o. l.* Fig. 4. drops out and leaves the block in the form Fig. 5. You will now observe that if in the last operation, instead of stopping the saw at the central diagonal *k. l.* we had cut through the block in the same plane, we should have taken off a wedge *l. m. n. o. k. b.* Fig. 3. and left the block in the form of a wedge also *l. o. k. b. a. p. k.* which, when speaking of the principle of the mould-board, I observed would be the most perfect form if it had only to raise the sod. But as it is to be turned over also, the left half of the upper wedge is preserved, to furnish on the left side, the continuation of the bevil which was proposed to be made on the right half of the bottom wedge. We are now to proceed to the bevil, for which purpose the scribes round the block were formed before the pyramidal piece was taken out; and attention must be used not to mismatch or mistake them, now that they are disjoined by the withdrawing of that piece. Enter the saw on the two points of the 1st scribe where it has been disjoined, which is exactly where it intersected the two superficial diagonals, and saw across the hollow of the block, guiding the saw, both before and behind, along the same scribe, till the fore part of the saw reaches the bottom edge of the right side, and the middle of the saw reaches the central diagonal; the

the hinder part will of course continue the same straight line, which will issue somewhere on the top of the block. Then enter the saw in like manner on the two projecting points of the 2d scribe, and saw in, along the scribe, before and behind, till it reaches the same bottom edge of the right side, and the central diagonal. Then the 3d, 4th, 5th, &c. scribes successively. After cutting in several of the earlier scribes, the hinder part of the saw will issue at the left side of the block, and all the scribes being cut, the saw will have left straight lines from the bottom edge of the right side of the block, across the central diagonal. With an adze dub off all the sawed parts to the bottoms of the saw-marks, just leaving the traces visible, and the face of the mould-board is finished. These traces will shew how the cross wedge rises gradually on the face of the direct wedge, which is preserved in trace of the central diagonal. A person may represent to himself, sensibly and easily the manner in which the sod is raised on this mould-board, by describing on the ground a parallelogram 2 feet long and 9 inches broad, as *a. b. c. d.* Fig. 6. then rest one end of a stick  $27\frac{1}{2}$  inches long on the ground at *b.* and raise the other 12 inches high at *e.* which is  $4\frac{1}{2}$  inches from *d*, and represents the overhanging of that side of the mould-board. Then present another stick 12 inches long from *a.* to *b.* and move it backwards parallel with itself from *a. b.* to *d. c.* keeping one end of it always on the line *a. d.* and letting the other rise as it recedes along the diagonal stick *b. e.* which represents our central diagonal. The motion of the cross stick will be that of our rising wedge, and will shew how every transverse line of the sod is conducted from its first horizontal position, till it is raised so far beyond the perpendicular as to fall reversed by its own weight. But to return to our work. We have still to form the under side of the mould-board. Turn the block bottom up. Enter the  
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the saw on the 1st scribe, at what was the bottom edge of the left side, and cut in, guiding the instrument at both ends by the scribe, till it has approached within an inch, or any other distance according to the thickness you choose, of the face. Then cut in like manner all the other scribes, and with the adze dub out the sawed parts, and the mould-board is done. It is to be made fast to the plough by resting the toe in the hinder edge of the wing, which must be made double like a comb-case, to receive and protect the fore end of the mould-board. Then pass a screw through the mould-board and helve of the ploughshare where they touch each other, and two others through the tail-piece of the mould-board and right handle of the plough, and cut off so much of the tail-piece as projects behind the handle, diagonally, and the whole is done.

I have described this operation in its simplest mode, that it might be the more easily understood. But, in practice, I have found some other modifications of it advantageous. Thus, instead of first forming my block as *a. b. c. d.* Fig. 7. where *a. b.* is 12 inches, and the angle at *b.* a right one, I cut a wedge-like piece *b. c. e.* off of the bottom through the whole length of the block, *b. e.* being equal to the thickness of the bar of the share (suppose  $1\frac{1}{2}$  inches) because the face of the wing declining from the top of the bar to the ground, were the block laid on the share, without an equivalent bevil at its bottom, the side *a. b.* would decline from the perpendicular, and *a. d.* from its horizontal position. Again, instead of leaving the top of the block  $13\frac{1}{2}$  inches wide from *m.* to *n.* Fig. 8. I cut a wedge from the right side *n. k. i. c. p. n.*  $1\frac{1}{2}$  inches thick at top and tapering to nothing at bottom; because I find that the tail-piece, being by this means made oblique, as *c. i.* instead of *k. i.* is brought more advantageously to the side of the handle. The first superficial diagonal is consequently brought from *m.* to *c.* and  
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not from *m.* to *k.* as in the first directions. These variations will be easy to any one after understanding the general principle. While these mould-boards have been under trial, and essays have been making of greater or less projections for the upper right edge of the block, and of different heights in proportion to the depth of the furrow, I have continued to make them of wood. But now satisfied by a sufficient experience, that for a furrow of 9 by 6 inches, the dimensions I have stated are the best, I propose to have the mould-board made of cast iron.

I am sensible that this description may be thought too lengthy and elaborate for a subject which has hardly been deemed worthy the application of science. But if the plough be in truth the most useful of the instruments known to man, its perfection cannot be an idle speculation. And in any case whatever, the combination of a *theory* which may satisfy the learned, with a *practice* intelligible to the most unlettered labourer, will be acceptable to the two most useful classes of society. Be this as it may, from the widow her mite only was expected. I have contributed according to my poverty; others will from their abundance.—None so much as yourself, who have been the animating principle of the institution from its first germ. When I contemplate the extensive good which the proceedings under your direction are calculated to produce, I cannot but deplore every possibility of their interruption. I am fixed in awe at the mighty conflict to which two great nations are advancing, and recoil with horror at the ferociousness of man. Will nations never devise a more rational umpire of differences than force? Are there no means of coercing injustice more gratifying to our nature than a waste of the blood of thousands; and of the labour of millions of our fellow-creatures? We see numerous societies of men (the aborigines of this country) living together without the acknowledgment of either laws or magistracy. Yet they live in  
peace

peace among themselves, and acts of violence and injury are as rare in their societies as in nations which keep the sword of the law in perpetual activity. Public reproach, a refusal of common offices, interdiction of the commerce and comforts of society are found as effectual as the coarser instrument of force. Nations, like these individuals, stand towards each other only in the relations of natural right. Might they not, like them, be peaceably punished for violence and wrong? Wonderful has been the progress of human improvement in other lines. Let us hope then that that law of nature which makes a virtuous conduct produce benefit, and vice loss, to the agent in the long run, which has sanctioned the common principle that honesty is the best policy, will in time influence the proceedings of nations as well as of individuals; and that we shall at length be sensible that war is an instrument entirely inefficient towards redressing wrong; that it multiplies instead of indemnifying losses. Had the money which has been spent in the present war been employed in making roads and conducting canals of navigation and irrigation through the country, not a hovel in the remotest corner of the Highlands of Scotland, or mountains of Auvergne, would have been without a boat at its door, a rill of water in every field, and a road to its market town. Had the money we have lost by the lawless depredations of all the belligerent powers been employed in the same way, what communications would have been opened of roads and waters! Yet were we to go to war for redress, instead of redress, we should plunge deeper into loss, and disable ourselves for half a century more from attaining the same end. A war would cost us more than would cut through the isthmus of Darien; and that of Suez might have been opened with what a single year has seen thrown away on the rock of Gibraltar. These truths are palpable, and must in the progress of time have their in-

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fluence on the minds and conduct of nations. An evidence that we are advancing towards a better state of things may be gathered from the public patronage of your labours, which tend eminently to ameliorate the condition of man. That they may meet the success they merit, I sincerely pray, and that yourself may receive the patriot's best reward, the applauding voice of present and future times. Accept, I beseech you, mine, with assurances of the sentiments of great and sincere respect and esteem with which I have the honour to be, Dear Sir,

Your affectionate friend,

and humble servant,

TH. JEFFERSON.

*Experiments*

